

ated with warmer air. The oceanic wind turns and goes southwestward along the Piedmont. Aloft, the increasing southerly wind of the primary cyclone is slowly, but surely, wearing down the cold mass of air over the Piedmont. A stage is reached when the attacks from the northeast and from the southwest finally break through to the ground; and the remaining layer of cold air, turbulently mixed with the warmer air, goes north. The backbone of the secondary cyclone is thus removed. The fog blows away and skies clear.

The pressure over the Piedmont having fallen rapidly, in consequence of the replacement of the cold air by much warmer air now from far south, the seaward pressure gradient of the secondary is weakened and destroyed. The primary Low speeds forward where previously it had been delayed on approaching the band of cold air. A cyclone has been born, lived a day and died.

The foregoing description fits closely the conditions on Thanksgiving Day (Nov. 28), 1918 (see figs. 1 and 2). Partial developments are common in the colder half-year. On October 29, 1917, a weak secondary cyclone developed and lasted till nearly midnight, when the cold air was blown away violently and a tornado formed.¹

Two other examples may be cited. On the morning of December 24, 1918, there was an intense cyclone centered in Illinois. The winds on the middle Atlantic

coast were still northeasterly from a northeastern HIGH. By noon the wind at Manteo, on the coast of North Carolina, had become south, and by night the south wind had established itself on the coast north to Atlantic City, N. J., and a secondary had developed (see fig. 3.) The next morning, the primary center was over northern New York, and there was still a weak remnant of the secondary centered apparently in southeastern Connecticut. The rainfall was heavier about the secondary than close to the center of the primary cyclone. Part, if not all, of the excess, however, may have been the natural result of rainfall which usually accompanies warm on-shore winds in winter. A trough-like secondary developed overnight and was apparent on the weather map for 8 a. m., January 14, 1921 (see fig. 4). The contrast in temperature between the cold air inland and the warm wind on the coast was particularly great; at Norfolk, Va., there was a SE. wind of 30 miles an hour, with a temperature of 56° F., while at Richmond, 40 miles away, the wind was NW. at 6 miles an hour, with a temperature of 32°. The rain falling from the warm overriding wind froze into glaze over considerable areas in central and northern Virginia and northeastward. No rain fell where the surface wind was south, but where the strong wind rode up over the wedge of cold air heavy rains, locally more than 1 inch, fell.

I am indebted to Mr. C. LeRoy Meisinger for making the portions of the synoptic charts reproduced as figures 1 to 4.

¹ See MO. WEATHER REV., Oct., 1918, 46:460-464. Weather maps for the evening of Oct. 29 and the morning of the 30th are produced on p. 462, and diagrams showing local weather changes, on p. 463.

NOTE ON DEEP EASTERLY WINDS OVER THE MIDDLE WEST ON JANUARY 24, 25, AND 26, 1921.

By LEROY T. SAMUELS, Observer.

[Weather Bureau, Washington, D. C., Feb. 19, 1921.]

551.55 (77)

SYNOPSIS.

Kite flights and pilot balloon observations made in the north-central portion of the United States on January 24, 25, and 26, 1921, showed easterly winds persisting to heights of 3 kilometers or more. Easterly winds at these altitudes are rare in the United States during the winter season on account of the strong latitudinal temperature gradients usually existing. Pressure was generally high to the north of this region and low in the south, with a moderately steep surface temperature gradient extending from south to north. A large temperature inversion at Ellendale, however, caused the pressure to remain higher over this region, at least to 3 kilometers, than at Drexel where isothermal conditions obtained to 2,500 meters elevation.

On January 24, 25, and 26, 1921, upper-air soundings made in the north-central portion of the United States by means of kites and pilot balloons showed easterly winds extending from the surface to unusual heights. As is well known, easterly winds of considerable depth are rare in this country during the winter season, on account of the steep latitudinal temperature gradients usually existing. When such winds are found, they indicate that abnormal causative conditions prevail and it is well worth while to inquire, in some detail, what those conditions are.

During the period under consideration pressure was generally high north of the Canadian border, and low over the central and southern portions of the United States. On the morning of the 24th a HIGH (30.7 inches)

was central over Manitoba, and a LOW (29.75 inches) over western Kansas. Accompanying this pressure distribution was a moderately steep surface-temperature gradient extending from south to north with 0° C. at Omaha and -24.4° C. at Winnipeg. By the 26th the HIGH (30.7 inches) was central over Ontario and the LOW (30.05 inches) over southern Alabama, still showing a strong surface-temperature gradient ranging from -6.7° C. at Indianapolis to -28.9° C. at Stonecliffe, Ontario.

As a rule, under conditions like those just described there is found at a short distance above the surface a complete reversal in the pressure distribution, because the cold, and therefore denser, air in the north causes a diminution of pressure in the higher levels and the warmer air in the south tends to increase the pressure aloft, thus causing a reversal of the wind direction found at the surface.¹

As already stated, however, no such wind reversal was found, but instead an easterly component persisted to altitudes of 4 to 5 kilometers. The extent and duration of the easterly winds are shown in Table 1. The observations may be briefly summarized as follows:

¹ Gregg, W. R.: Note on high free-air wind velocities observed Dec. 16-17, 1919. MO. WEATHER REV., Dec., 1919: 47: 853-854.

TABLE 1.—Free-air winds observed in the north-central part of the United States on Jan. 24, 25, 26, and 27, 1921.

Stations.	January—	Time (local standard).	Altitude (meters) above sea-level.													
			Surface.		500		1,000		1,500		2,000		2,500		3,000	
			Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).
Ellendale, N. Dak.	24	8:45 a. m.	ene.	3	e.	5	e.	13	e.	10	ene.	5	ne.	8	ene.	3
	24	3:20 p. m.	ne.	9	ne.	8	e.	11	ese.	13	e.	10	e.	9	e.	8
	25	9:00 a. m.	nne.	4	nne.	3	se.	4	se.	6	se.	8	e.	6	ene.	8
	25	2:20 p. m.	sse.	2	sse.	2	se.	4	s.	2	w.	3	ene.	1	ene.	2
	26	8:35 a. m.	sse.	7	sse.	8	ssw.	6	sw.	6	ssw.	7	sw.	10	sw.	9
	1 24	8:33 a. m.	ne.	5	ne.	7	ene.	13	ene.	10	ene.	7	e.	6	ese.	6
	1 24	12:54 p. m.	ene.	9	ene.	9	ene.	13	ene.	14	ene.	11	ene.	8	ene.	7
	1 24	4:48 p. m.	ne.	8	ne.	9	ene.	14	e.	13	e.	11	ese.	10	ese.	12
	1 24	8:41 p. m.	nne.	6	nne.	7	e.	12	e.	11	ese.	11	ese.	10	ese.	11
	1 25	1:27 a. m.	nne.	4	ne.	5	e.	11	e.	10	e.	11	e.	8	e.	6
	1 25	8:14 a. m.	e.	12	e.	13	e.	18	ese.	16	ese.	13	se.	12	se.	12
	1 25	12:45 p. m.	ne.	6	ne.	8	ne.	9	nne.	7	nne.	6				
Fort Omaha, Nebr.	24	8:24 a. m.	e.	6	e.	8	ese.	17	ese.	14	ese.	14	se.	9	se.	11
Madison, Wis.	24	2:49 p. m.	ne.	8	ne.	6	ene.	6	ne.	7	unw.	6				
	25	7:17 a. m.	ne.	6	ene.	7										
	25	2:57 p. m.	e.	10	e.	10	e.	10								
	26	7:18 a. m.	ene.	4	e.	4	e.	4								
Royal Center, Ind.	25	7:08 a. m.	e.	11	e.	10	e.	9	e.	8						
	25	1:59 p. m.	ene.	12	e.	12	ese.	13	ese.	10	ese.	7	se.	6	sw.	6
	26	7:16 a. m.	ne.	8	ene.	11	e.	13	e.	12	e.	12	e.	11		
	26	2:03 p. m.	ne.	5	ene.	4	ene.	6	e.	7	ene.	5	e.	7	ene.	6
	27	7:02 a. m.	se.	2	ne.	2	n.	3	w.	3	w.	5	w.	5	wnw.	6
	1 26	8:16 a. m.	ene.	8	ene.	11	e.	11	e.	11	e.	10	e.	10	e.	11
	1 26	11:46 a. m.	ne.	6	ne.	7	ene.	7	e.	8	e.	7	e.	7		
	1 26	3:45 p. m.	ne.	4	ne.	4	nne.	2	ene.	2						
Lansing, Mich.	1 26	7:43 p. m.	nne.	3	ne.	4	e.	2								
	25	7:00 a. m.	ene.	4	e.	7										
	25	2:57 p. m.	ene.	3	ene.	6	e.	7	e.	9	ne.	8	nne.	6	nnw.	6
	26	6:55 a. m.	e.	3	ene.	5	e.									
	26	3:02 p. m.	ne.	1	n.	2	e.	2	e.	10	n.	1	w.	3	w.	4

Stations.	January—	Time (local standard).	Altitude (meters) above sea-level.													
			3,500		4,000		4,500		5,000		6,000		7,000		8,000	
			Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).	Direction.	Velocity (m. p. s.).
Ellendale, N. Dak.	24	8:45 a. m.	e.	2	sse.	1										
	24	3:20 p. m.	ese.	6												
	25	9:00 a. m.	ene.	6	ene.	5										
	25	2:20 p. m.	n.	3	nnw.	4	nnw.	4	nnw.	6						
	26	8:35 a. m.	sw.	9												
	1 24	8:33 a. m.	se.	5												
	1 24	12:45 p. m.														
	1 24	4:48 p. m.														
	1 24	8:41 p. m.	se.	8												
	1 25	1:27 a. m.	se.	13												
	1 25	8:14 a. m.														
	1 25	12:45 p. m.														
Drexel, Nebr.	24	8:24 a. m.														
Fort Omaha, Nebr.	24	2:49 p. m.														
Madison, Wis.	24	7:17 a. m.														
	25	2:57 p. m.														
	26	7:18 a. m.														
	25	7:08 a. m.														
Royal Center, Ind.	25	1:59 p. m.	sw.	9												
	26	7:16 a. m.														
	26	2:03 p. m.	ne.	7	ene.	7	ne.	8	nne.	8						
	27	7:02 a. m.	nnw.	8												
	1 26	8:16 a. m.														
	1 26	11:46 a. m.														
	1 26	3:45 p. m.														
	1 26	7:43 p. m.														
Lansing, Mich.	25	7:00 a. m.														
	25	2:57 p. m.														
	26	6:55 a. m.														
	26	3:02 p. m.	wnw.	4	wnw.	6	wnw.	6	wsu.	6	wnw.	7	nnw.	13	nw.	26

¹ Observations from kite flights; all others from pilot balloon ascents; altitudes in the latter are determined from an assumed constant rate of ascent.

² Less than 0.5 m. p. s.

NOTE.—The altitudes of the stations above sea-level are: Ellendale, 444 meters; Drexel, 396 meters; Fort Omaha, 350 meters; Madison, 307 meters; Royal Center, 226 meters; Lansing, 263 meters.

Five kite flights were made at Ellendale, N. Dak., from 8:33 a. m., January 24 to 5:05 a. m., January 25. It was impossible to continue the series, as a sixth flight reached an altitude of only 350 meters above the surface, due to diminishing wind velocities. In all of these flights easterly winds prevailed to the highest altitudes reached. Pilot balloon ascensions at Ellendale on the 24th, likewise indicated easterly winds with decreasing velocities in the higher levels up to 3,600 meters and 3,400 meters for the a. m. and p. m. observations, respectively. In both cases the balloons burst before they had reached the A.St. cloud layer which was observed to be moving from the SW. On the morning of the next day, however, clouds were observed here as follows: 6/10 Ci.St., E., 1/10 A.St., E., and 2/10 A.Cu., E. The balloon during this run burst at the 3,500-meter level and indicated easterly winds to this height.

Four kite flights were made at Royal Center, Ind., from 8:16 a. m. to 9:30 p. m., January 26, and easterly winds were found at all altitudes reached. On the morning of the same day A.St. clouds were observed moving from the east but unfortunately the pilot balloon was obscured by the instrument tower when the 2,500-meter level was reached. The afternoon balloon run indicated an easterly wind to 4,000 meters shifting to north-northeast at 4,800 meters when the balloon was observed to burst.

At Lansing, Mich., the easterly winds were not of such great depth as at Ellendale and Royal Center. The afternoon balloon run of the 26th indicated northeast to south-east winds from the surface to 1,500 meters, then shifting through north to west and northwest to 8,000 meters, at which altitude the balloon was lost to view.

The cause of these easterly winds at high altitudes is made apparent by an examination of the free-air temperatures observed at Drexel and Ellendale. Figure 1 shows that on the morning of the 24th there was a large temperature difference at the surface, but that up to 2,500 meters practically isothermal conditions prevailed at Drexel, whereas there was a large inversion at Ellendale, the result being that in the upper levels the horizontal temperature gradient between the two stations was comparatively slight. The effect of this temperature distribution on the free-air pressures is shown in Table 2.

TABLE 2.—Free-air pressures at Ellendale, N. Dak., and Drexel, Nebr., on the morning of Jan. 24, 1921.

Station.	Altitude (meters) above sea level—							
	500	750	1,000	1,250	1,500	2,000	2,500	3,000
Ellendale.....	mb. 970.7	mb. 939.8	mb. 909.6	mb. 880.3	mb. 852.6	mb. 800.5	mb. 751.6	mb. 704.7
Drexel.....	962.6	932.8	904.2	876.7	850.0	798.5	750.0	704.3

It will be noted that the pressures at Ellendale remain higher than those at Drexel up to 3 kilometers. It is apparent, though, that a reversal occurred at a slightly greater altitude than this—a condition favorable for westerly winds, and this is in agreement with the observed northeastward movement of the A.St. clouds.

By the morning of the 25th the easterly winds extended to a still greater height, as shown by the pilot balloon and upper-cloud observations made at that time. Comparison of free-air temperatures in this case is not possible, owing to the relatively low altitude reached at Drexel, but it is to be noted that the daily weather map shows on this day a weaker latitudinal temperature grad-

ient than on the preceding day, and it is to be presumed that a correspondingly weak gradient prevailed in the upper levels. The same statement and deduction may be made with respect to the easterly wind that extended at least to 5 kilometers on the afternoon of the 26th at Royal Center. An isothermal condition existed during all four kite flights at Royal Center but because there

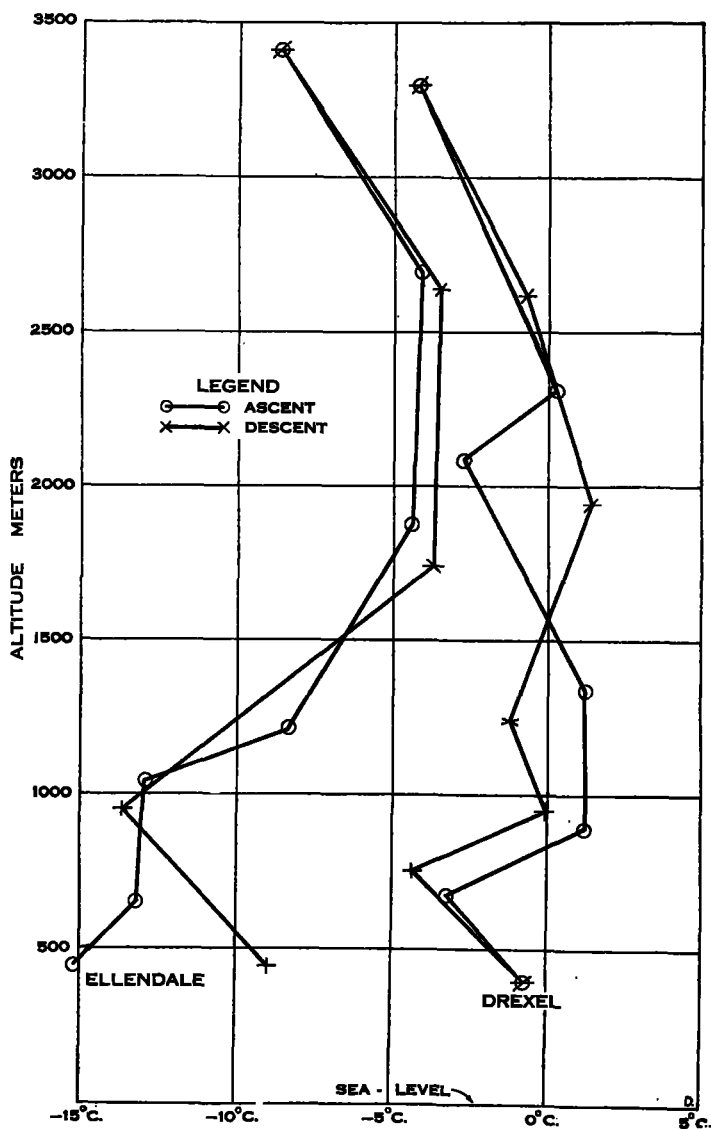


FIG. 1.—Simultaneous free-air temperatures, °C., at Ellendale, N. Dak., and Drexel, Nebr., on the morning of Jan. 24, 1921.

are no kite stations within a reasonable distance to the south, actual comparisons can not be made.

551.578.4 (756)

ICE STORM AND GALE OF JANUARY 25-27 AT WILMINGTON, N. C.

By R. M. DOLE, Observer.

[Weather Bureau, Wilmington, N. C., Jan. 30, 1921.]

The morning map of January 25 showed an oval depression in eastern Kansas which had moved to Mississippi by night and become a round and weak low surrounded by abnormally high pressure. The isobars were rather far apart, but the range in pressure and temperature to the northeastward was large, pressure being over 30.6